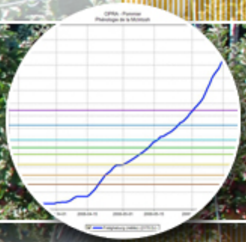
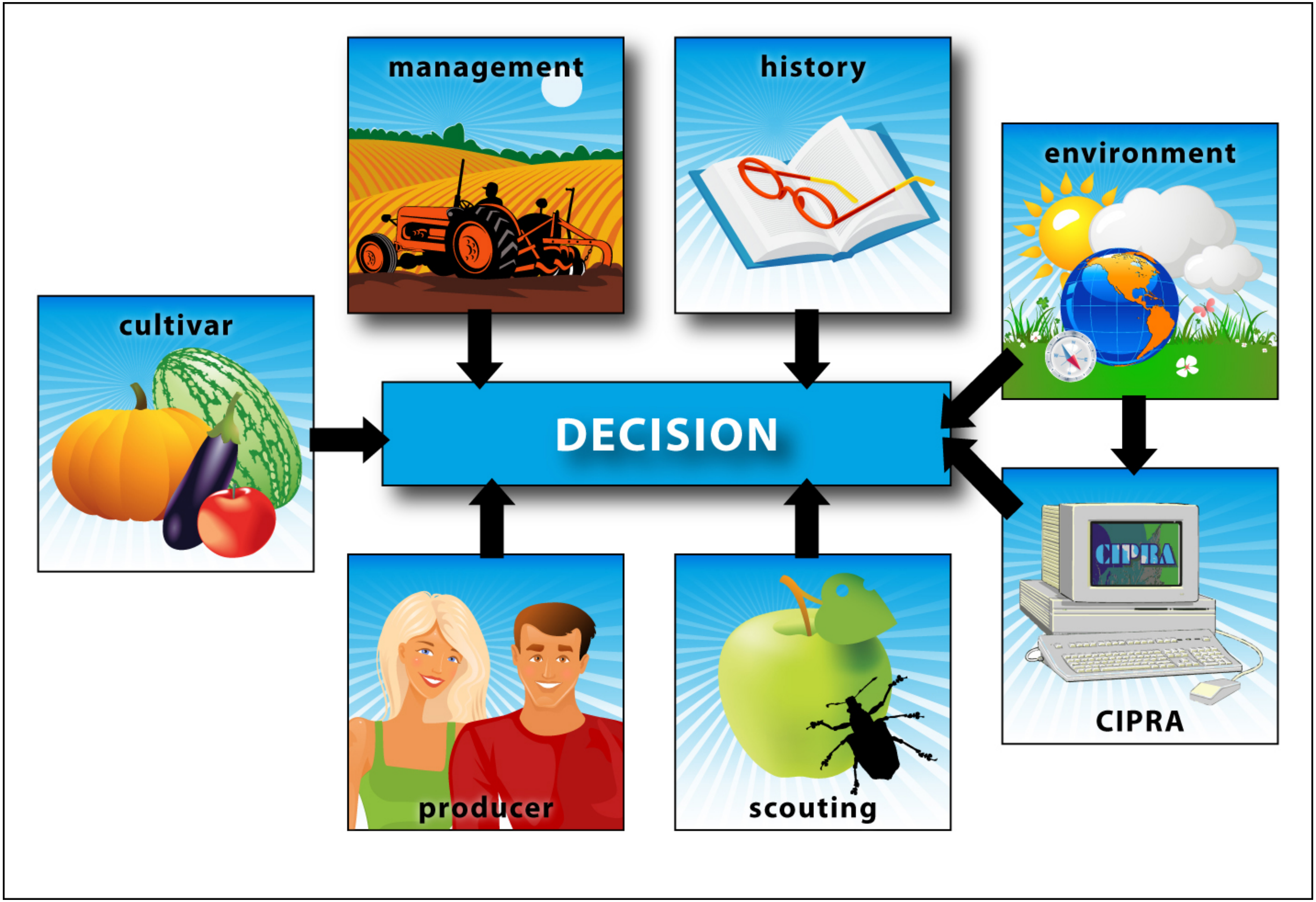
Agriculture et Agroalimentaire Canada
Agriculture and Agri-Food Canada

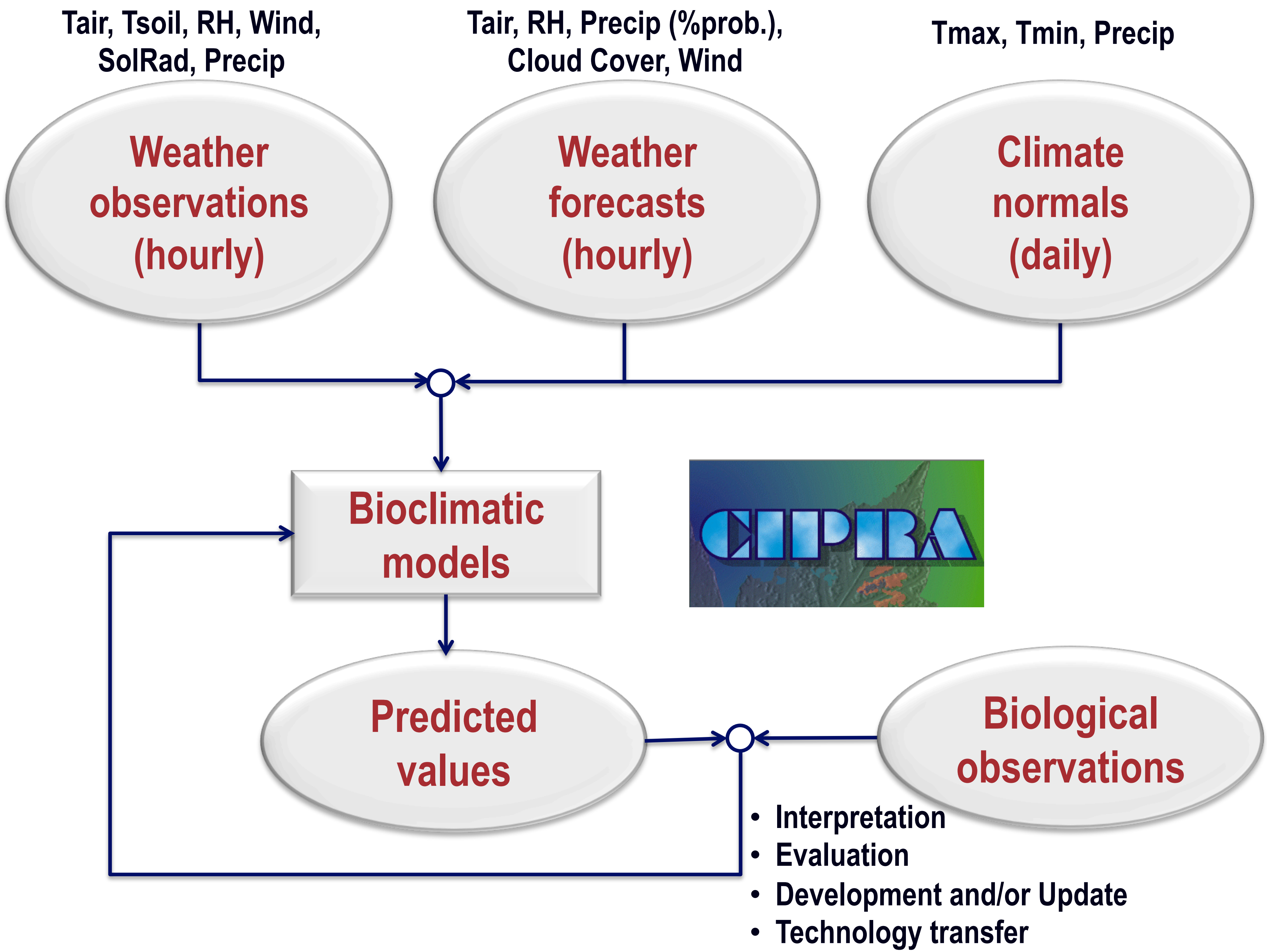


Bioclimatic modelling of crop-pest interactions to study the impacts of climate change and variability in Eastern Canada

Gaétan Bourgeois, Ph.D.
Saint-Jean-sur-Richelieu Research and Development Centre, QC

Canada


management
history
environment
cultivar
DECISION
CIPRA
producer
scouting

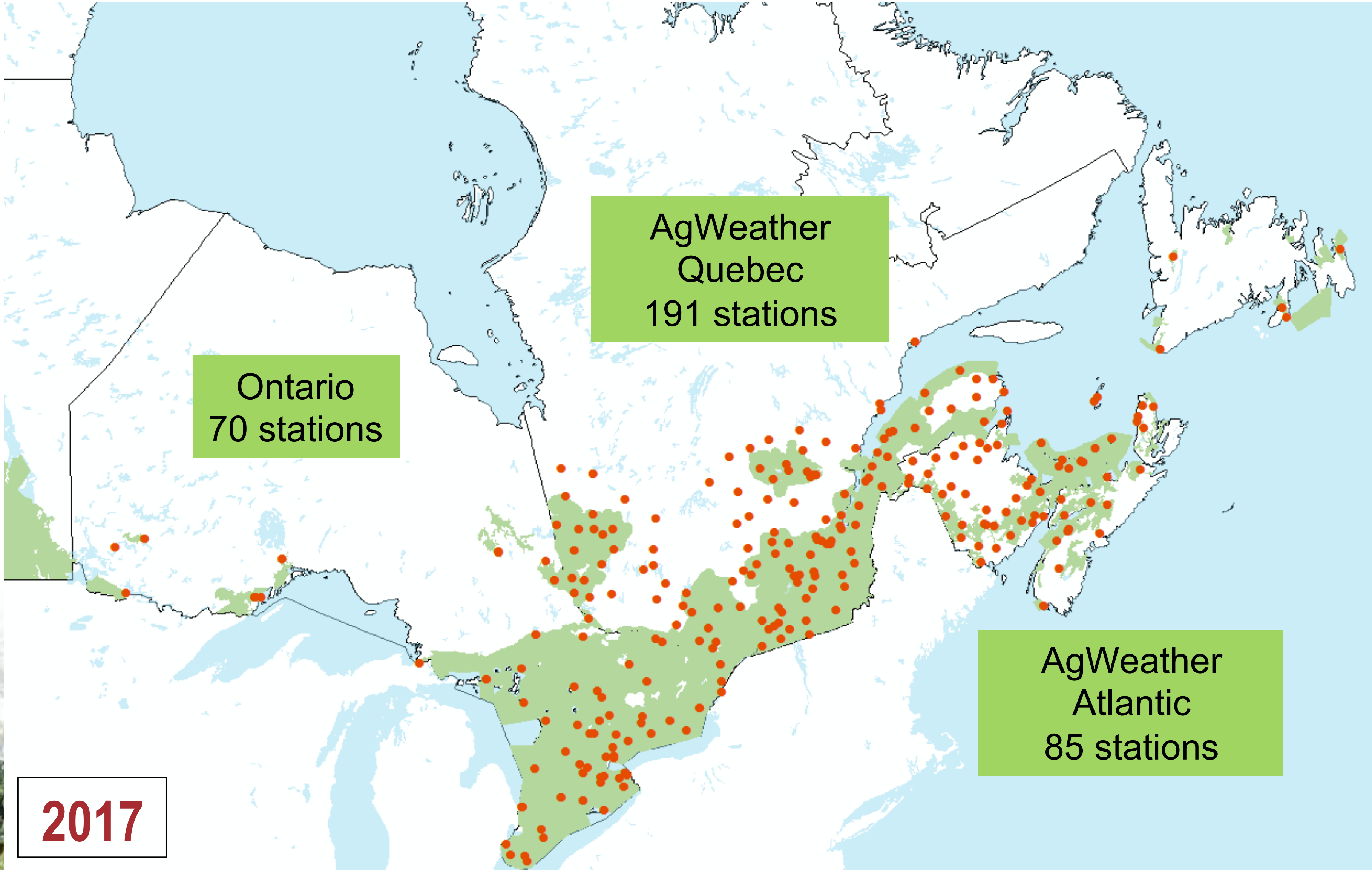

Tair, Tsoil, RH, Wind, SolRad, Precip
Tair, RH, Precip (%prob.), Cloud Cover, Wind
Tmax, Tmin, Precip
Weather observations (hourly)
Weather forecasts (hourly)
Climate normals (daily)
Bioclimatic models
CIPRA
Predicted values
Biological observations
• Interpretation
• Evaluation
• Development and/or Update
• Technology transfer

Computer Centre for Agricultural Pest Forecasting

>130 Bioclimatic models and indices → >25 Crops

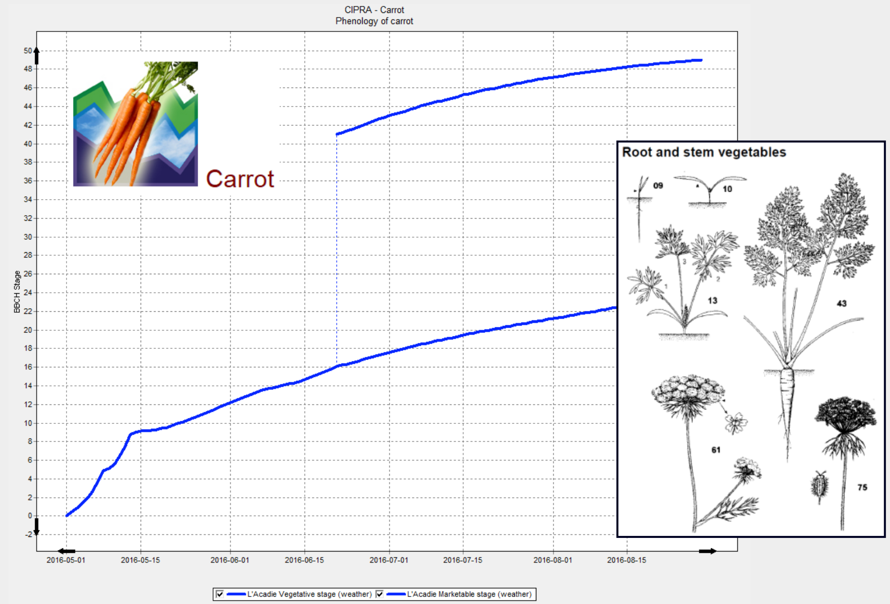
>250 Registered users → Thousands of crop producers

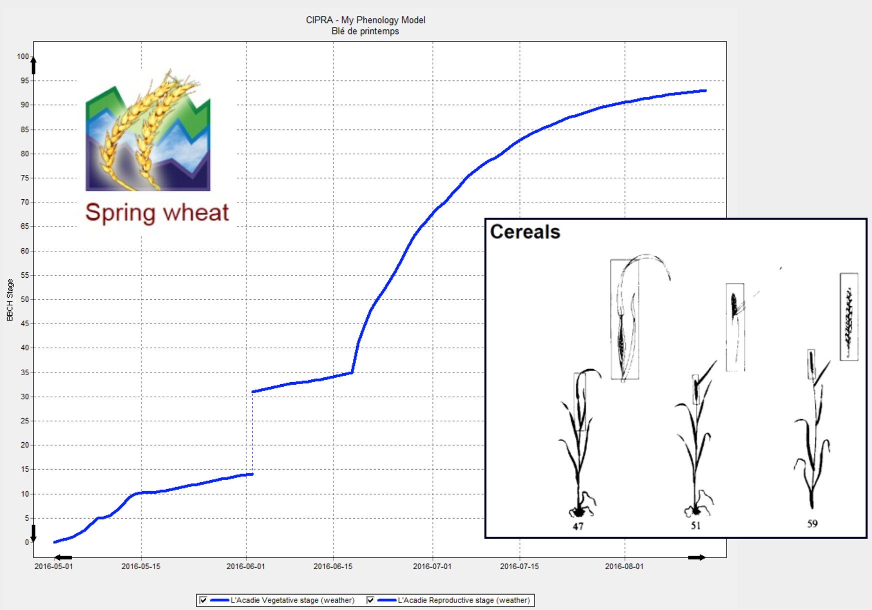
Operational weather network for bioclimatic models implemented in CIPRA for Eastern Canada (“real time”)

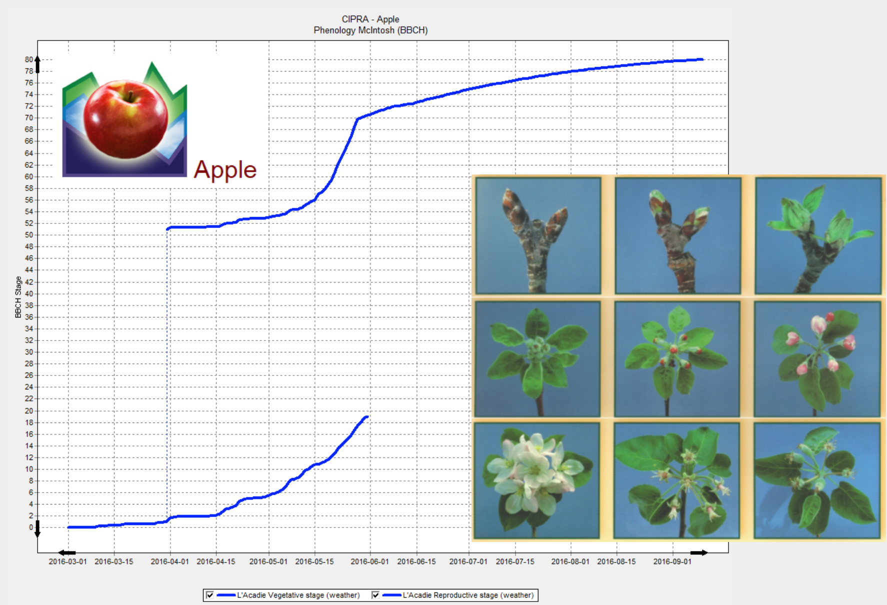


Predicting crop phenology (i.e. from seeding to harvest)

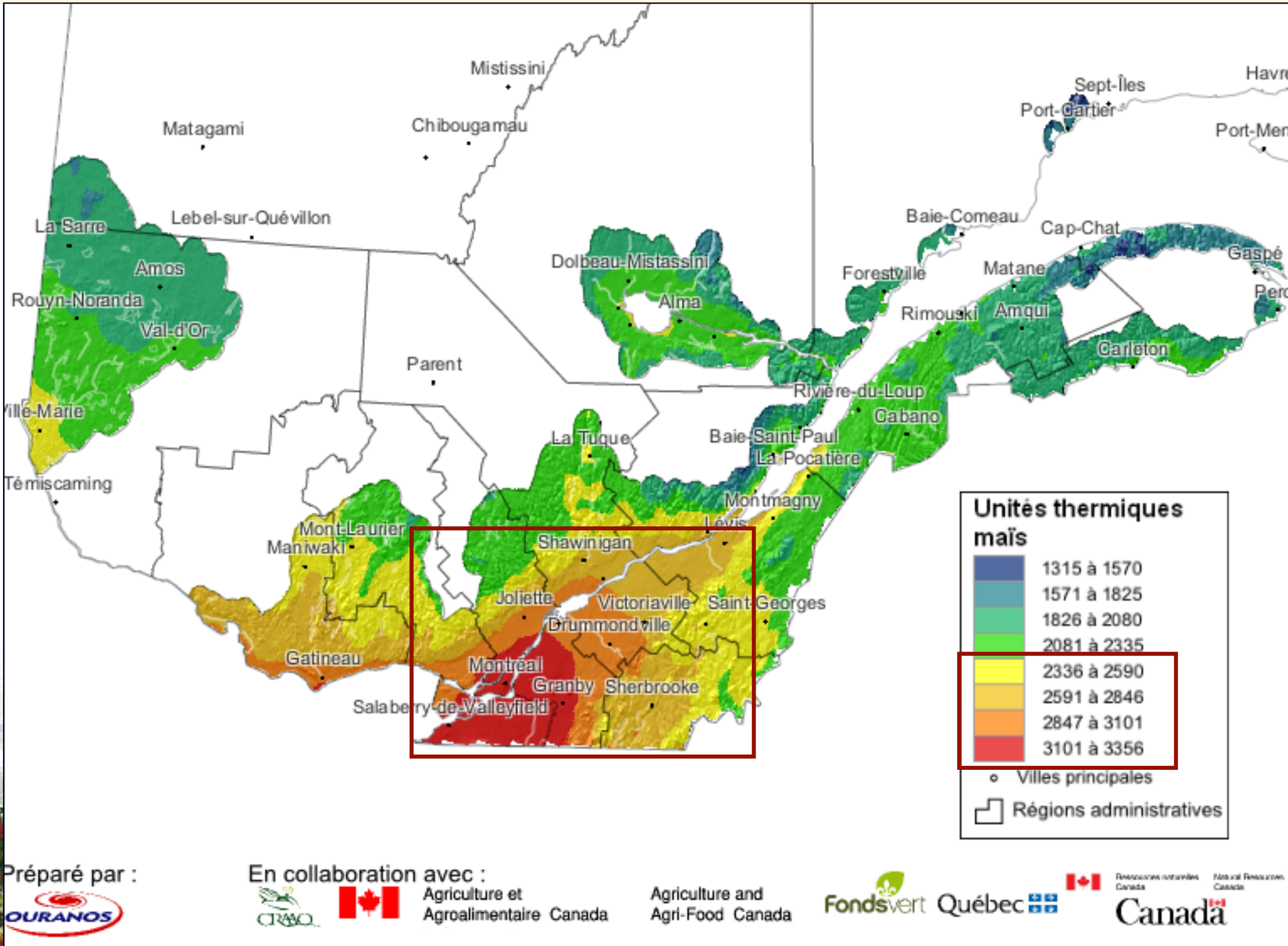
- Improves pest control and scouting strategies
- Better planning of seeding and crop harvest
- Great tool for marketing strategies
- Improves water and fertilizer management
- Key component for studies on impacts of climate change and variability



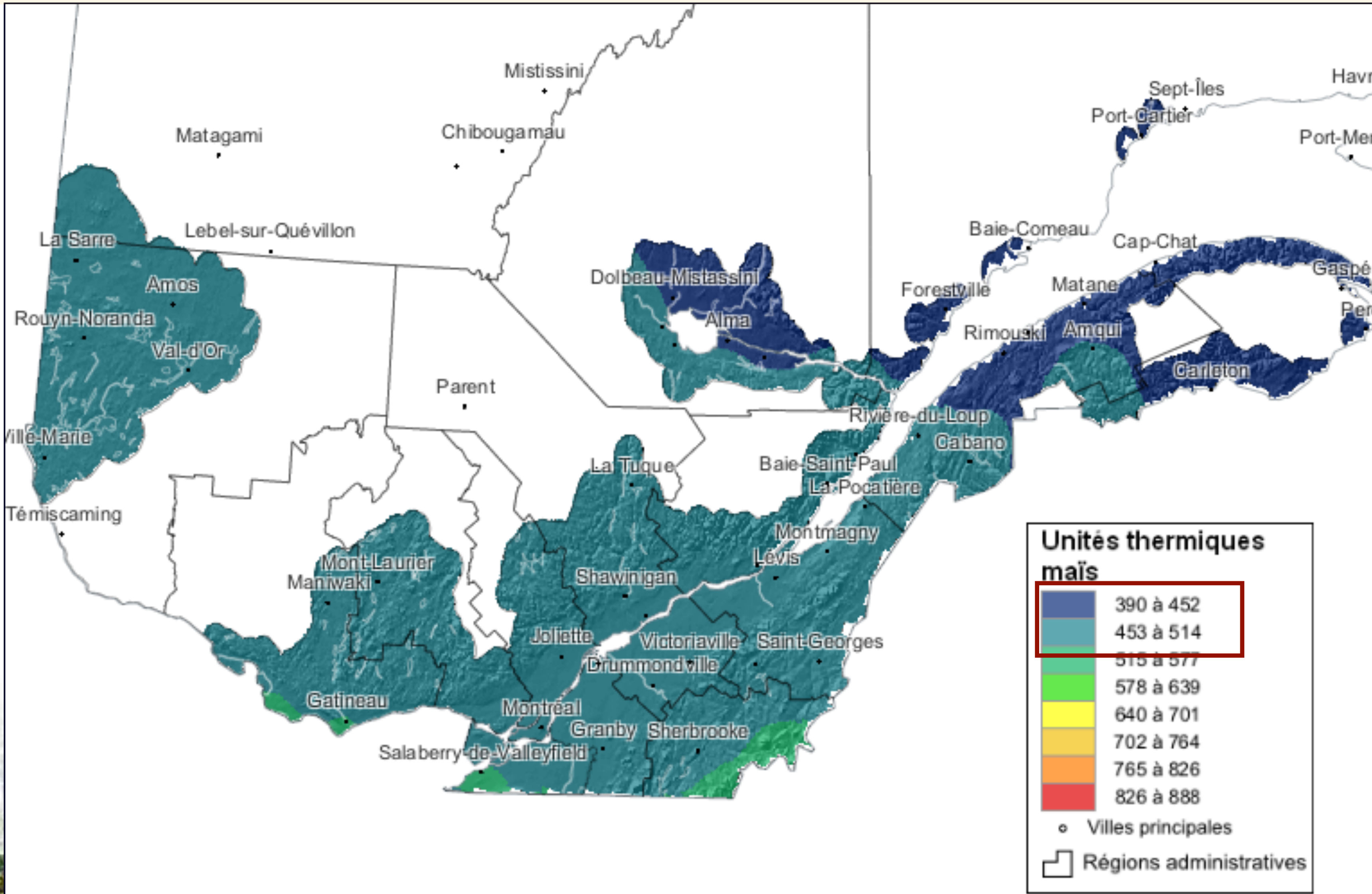




Cumulative corn heat units (CHU): 1979-2008



Change in corn heat units (CHU): 2041-2070 (Lower CC)



Préparé par :

OURANOS

En collaboration avec :

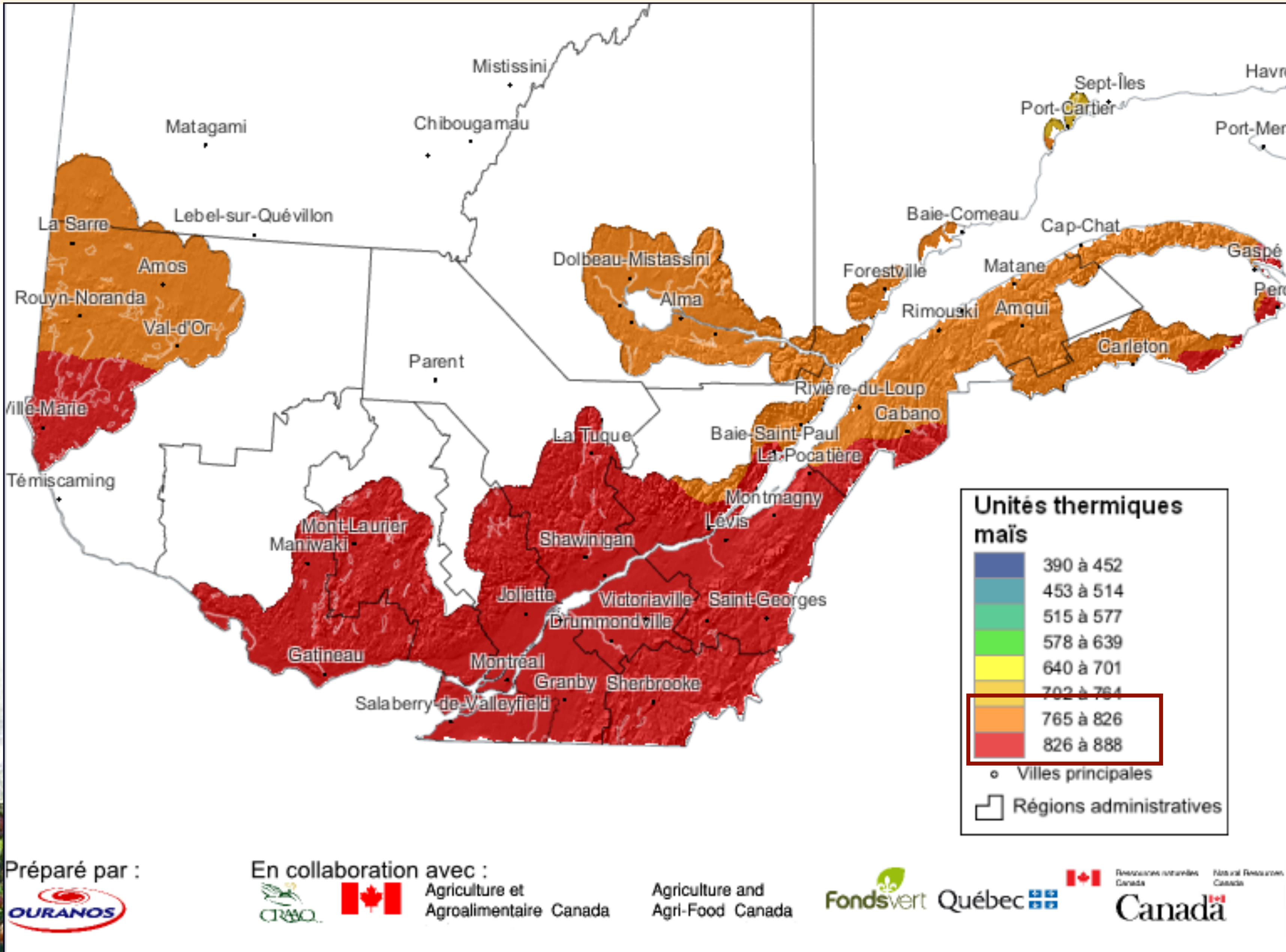
Agriculture et Agroalimentaire Canada

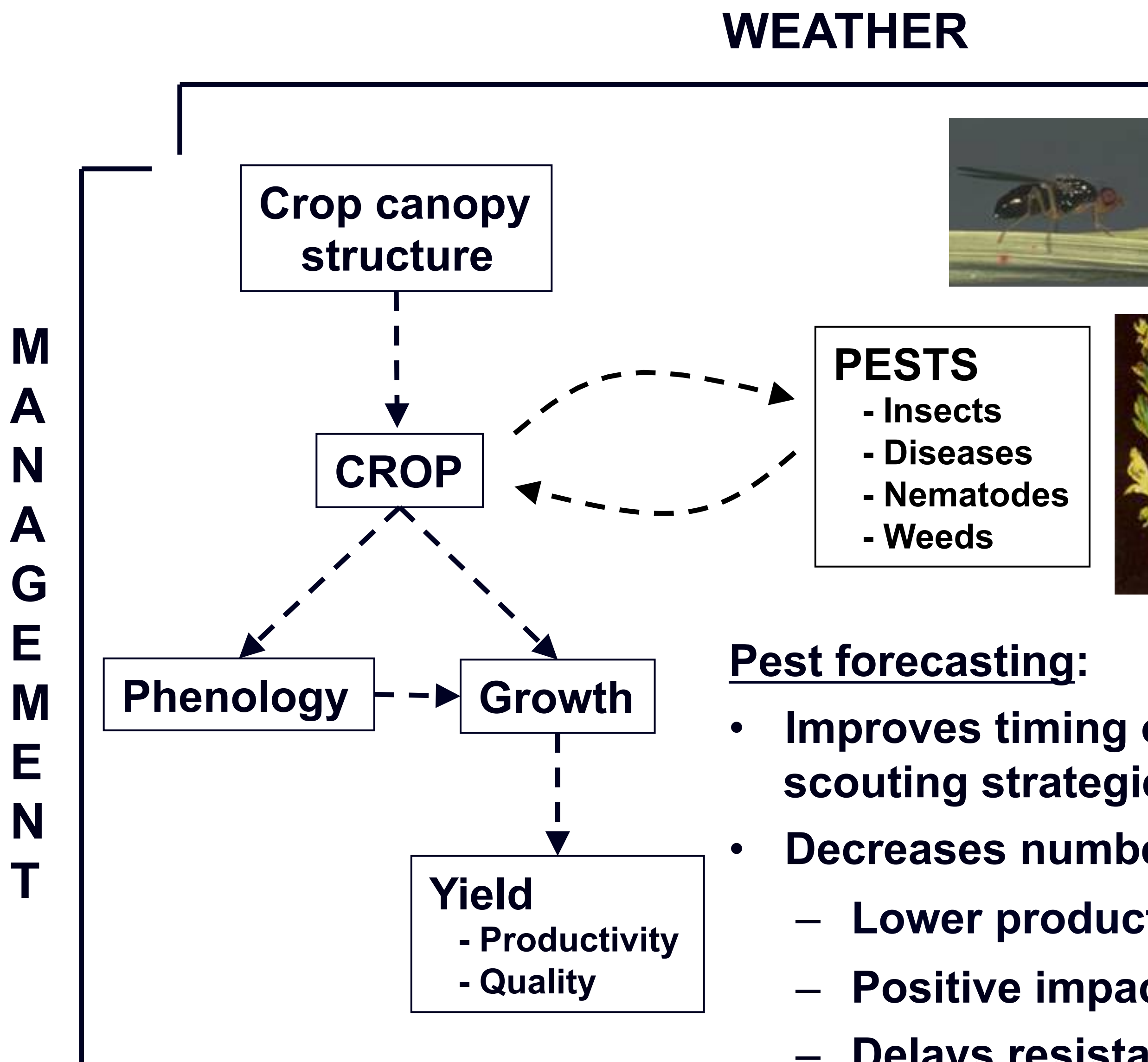
Agriculture and Agri-Food Canada

Fondsvert Québec

Canada

Change in corn heat units (CHU): 2041-2070 (Higher CC)

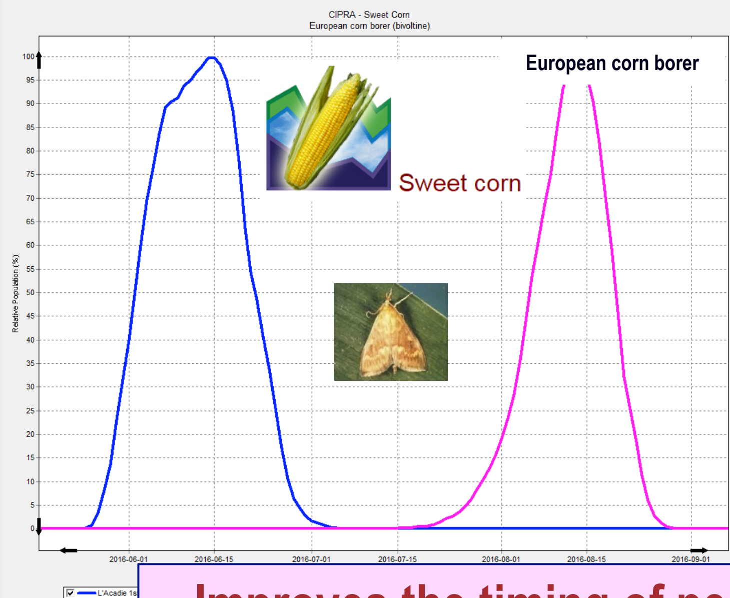


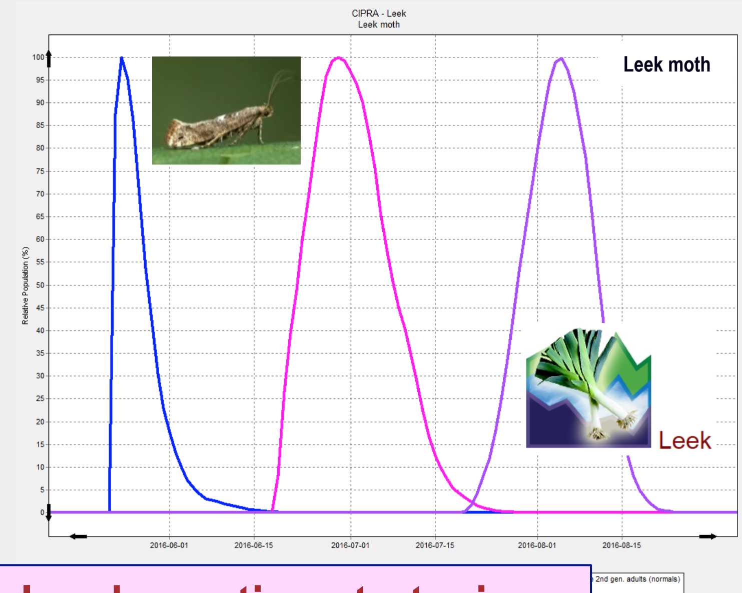


<u>Pest forecasting</u>:

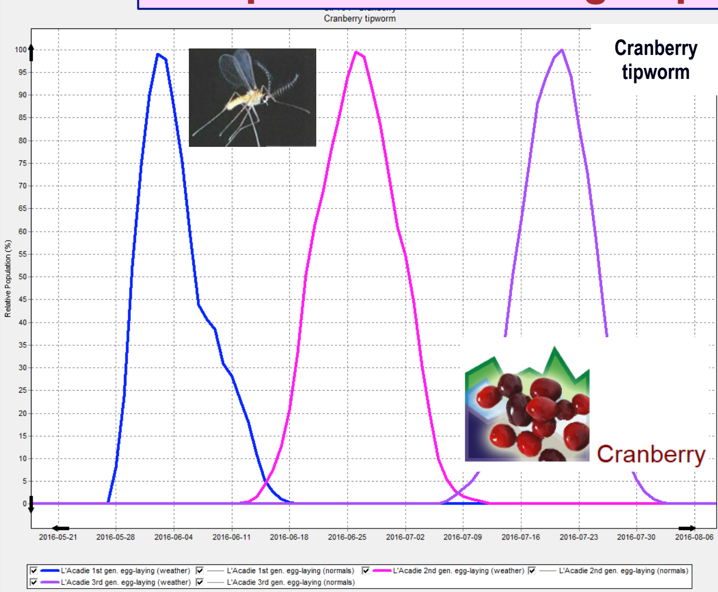
- **Improves timing of pest control and scouting strategies**
- **Decreases number of pesticide applications**
  - **Lower production costs**
  - **Positive impacts on the environment**
  - **Delays resistance development to pesticides**

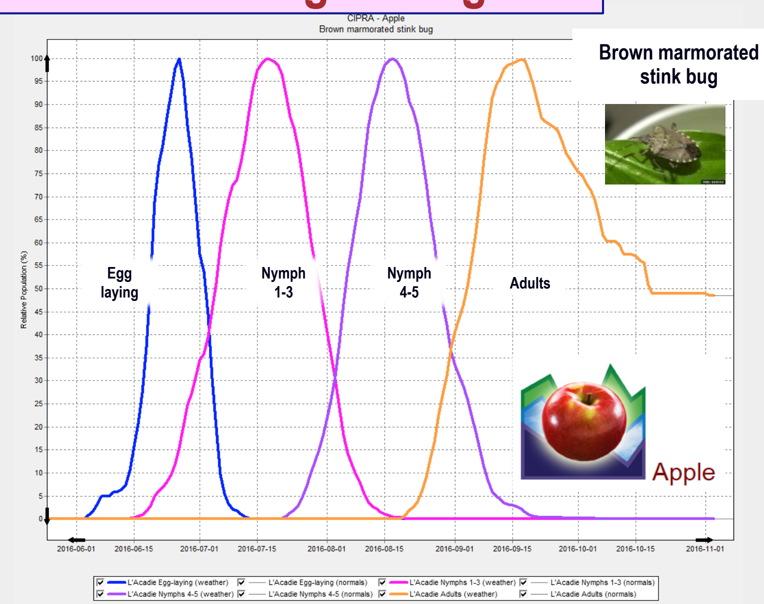
Predicting insect development for many crops



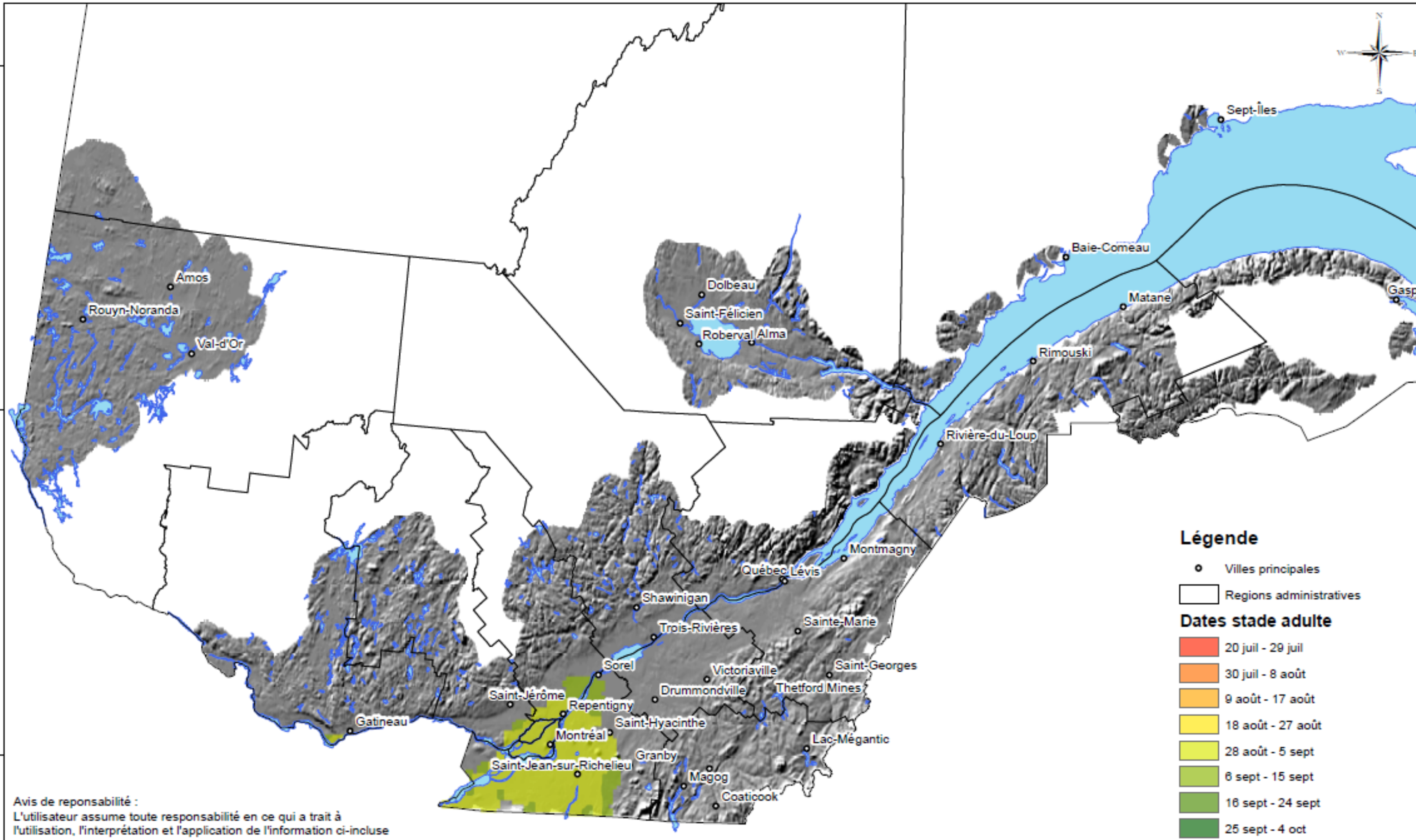


Improves the timing of pest control and scouting strategies





BMSB potential distribution in Quebec (1981-2010)



Sources :
Données climatiques quotidiennes maillées au 10km:
Gouvernement du Canada, Agriculture et Agroalimentaire Canada
Consortium OURANOS

Données de référence:
Ministère des Ressources naturelles Canada
Ministère des Ressources naturelles et de la Faune du Québec

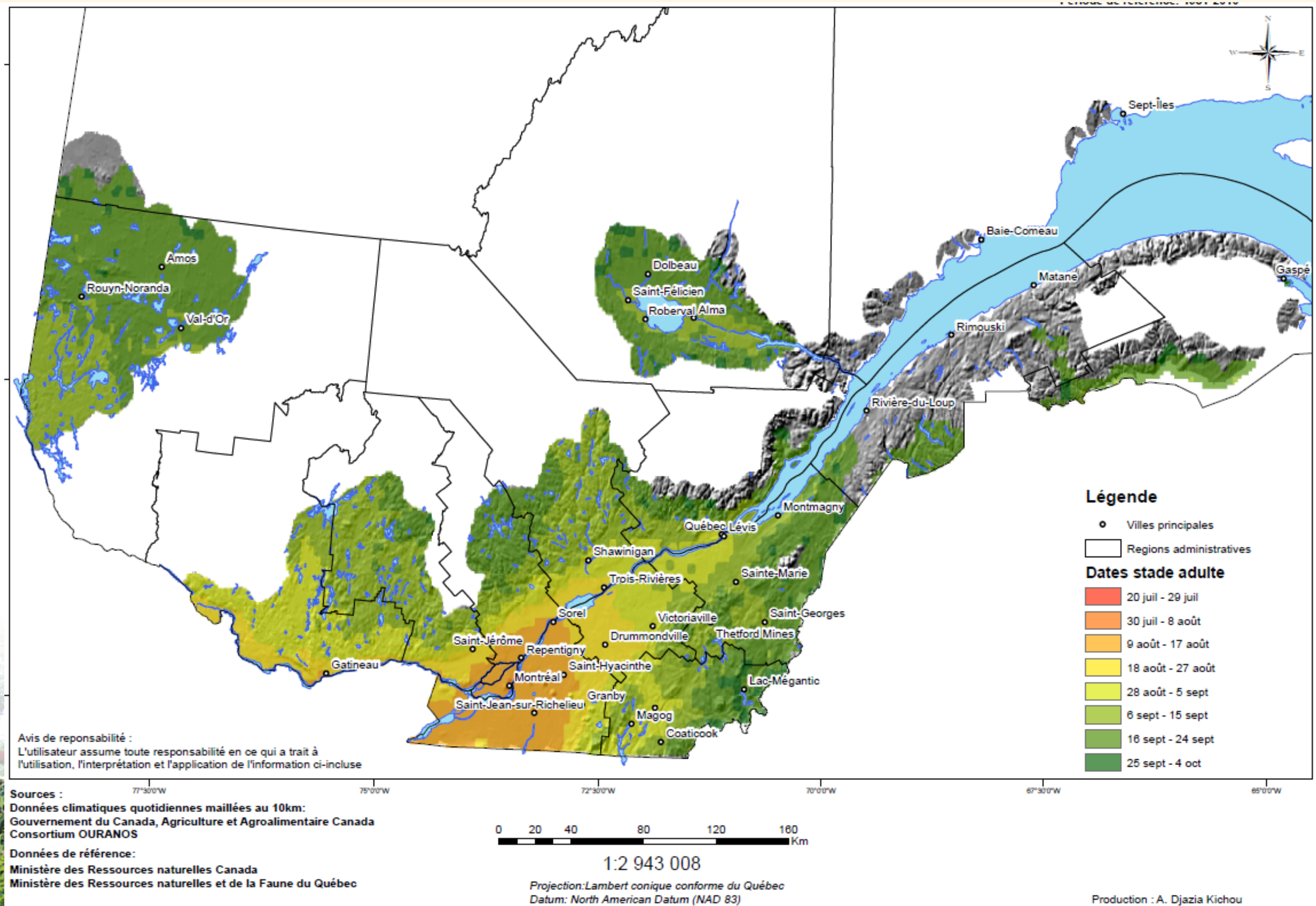
0 20 40 80 120 160 Km

1:2 943 008

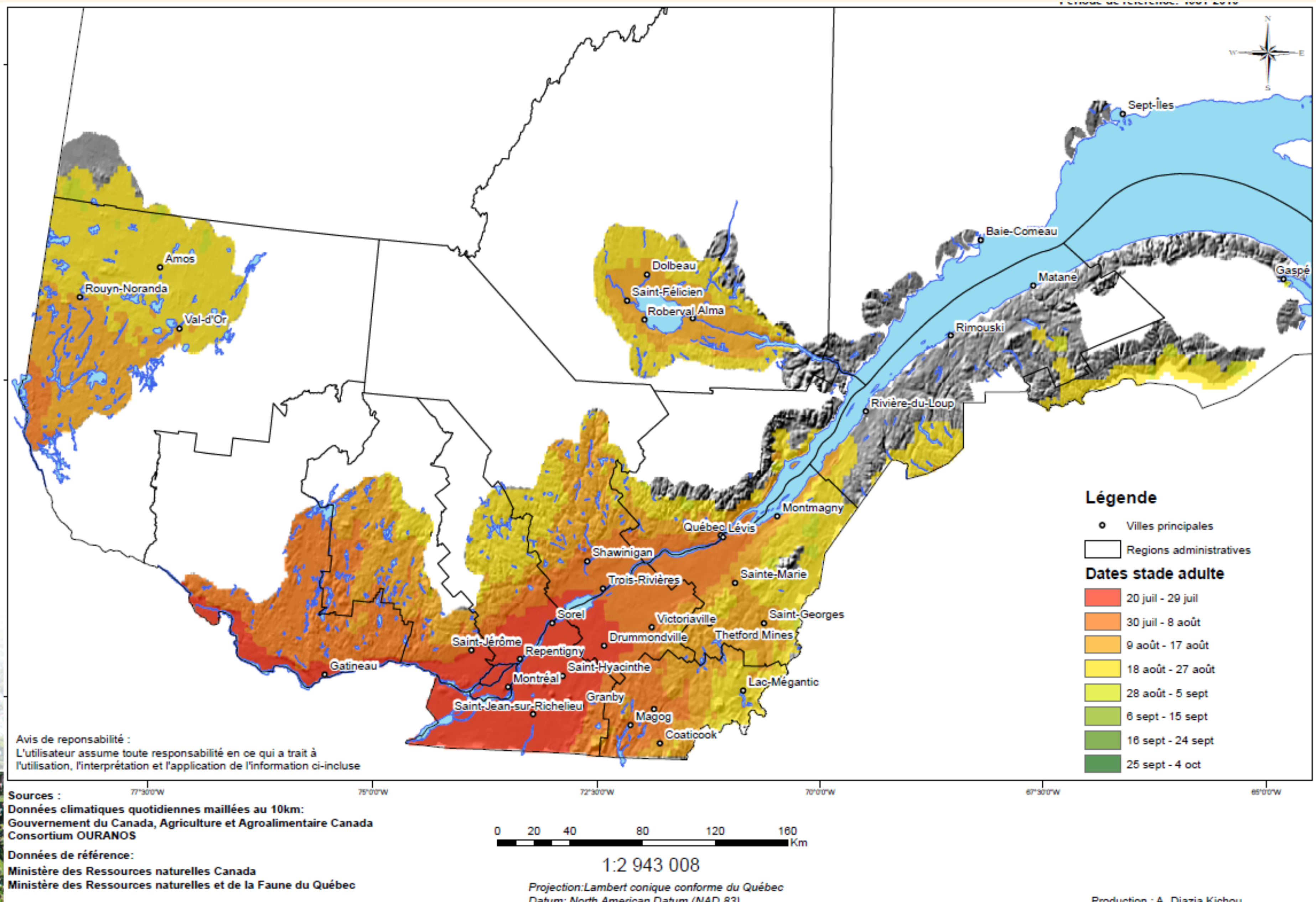
Projection:Lambert conique conforme du Québec
Datum: North American Datum (NAD 83)

Production : A. Djazia Kichou

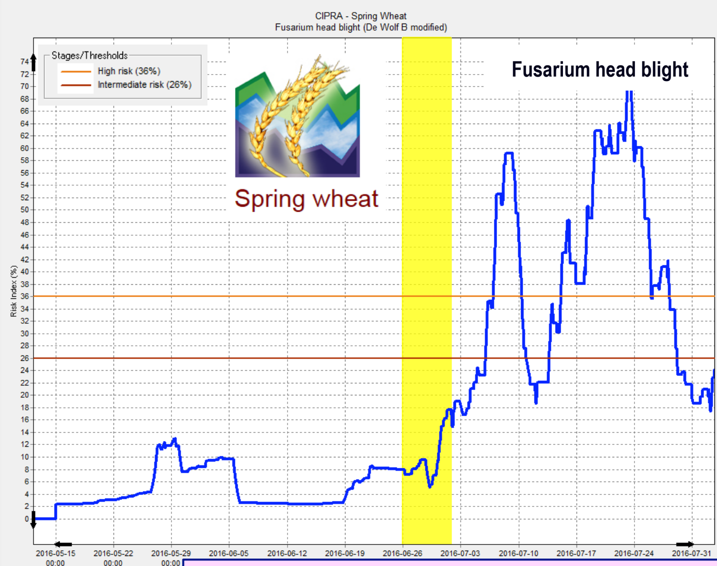
BMSB (Lower CC scenarios for 2041-2070)

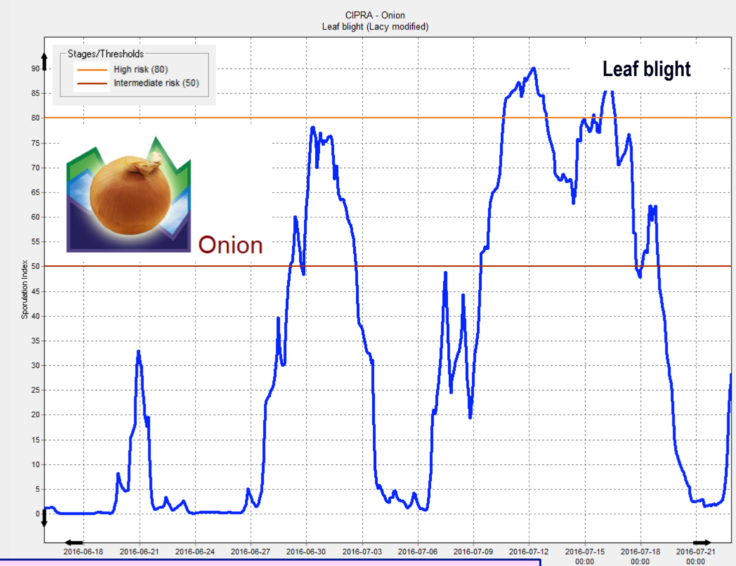


BMSB (Higher CC scenarios for 2041-2070)

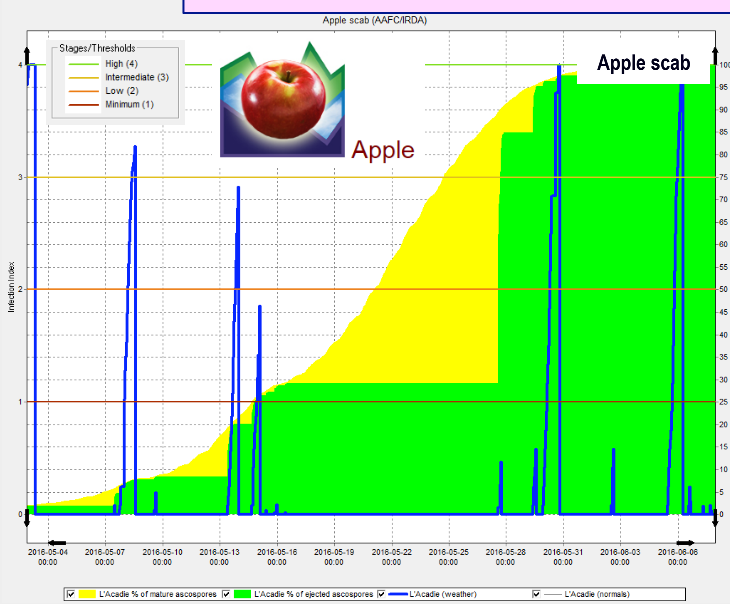


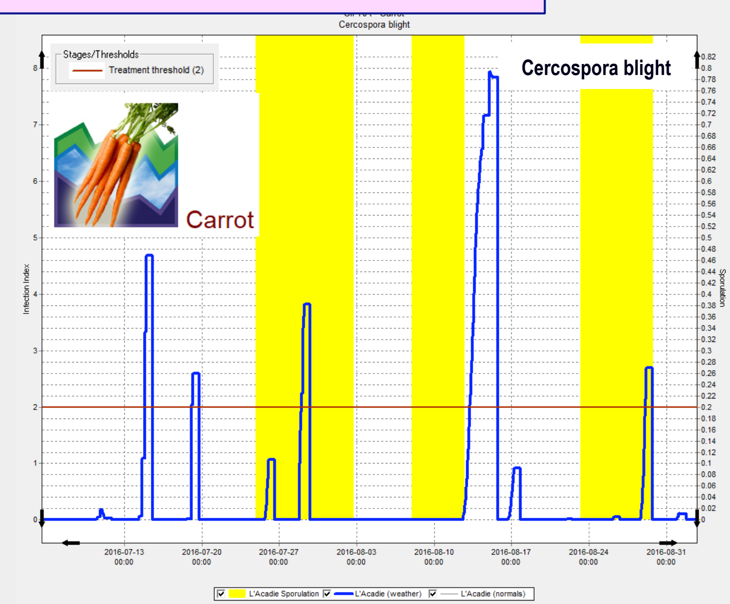
Disease forecasting for many crops





Decreases the number of pesticide applications





Disease forecasting for many crops

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journal homepage: www.elsevier.com/locate/agee

ELSEVIER

Climatic indicators for crop infection risk: Application to climate change impacts on five major foliar fungal diseases in Northern France

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[b] ACTA, 149 rue de Bercy, 75595 Paris,France
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2.1.1. General surface response function development

The Weibull equation, as modified by Duthie (1997), was used to model the daily infection efficiency (hereafter "ClimInfeR") as a surface response to both temperature and LWD (Fig. 1, Eq. (1)):

$$\mathrm{ClimInfeR}(d) = f(T)(1 - \exp\{-[A(\mathrm{LWD} - \mathrm{LWD}_0)]^B\}) \qquad (1)$$

$$\mathrm{ClimInfeR} = 0 \ \ \text{for} T < 0$$

The simple temperature response function $f(T)$ is a linear-plateau function with ascending and descending portions on both sides of the optimal plateau (Hartkamp et al., 2002) (Eq. (2)):

$$f(T) = \begin{Bmatrix} 0, & T \le T_{\min} \text{ and } T \ge T_{\max} \\ Y_{\max}, & T_{\mathrm{opt}1} \le T \le T_{\mathrm{opt}2} \\ \dfrac{Y_{\max}}{T_{\mathrm{opt}1} - T_{\min}}(T - T_{\min}), & T_{\min} < T < T_{\mathrm{opt}1} \\ \dfrac{Y_{\max}}{T_{\mathrm{opt}2} - T_{\max}}(T - T_{\max}), & T_{\mathrm{opt}2} < T < T_{\max} \end{Bmatrix} \qquad (2)$$

Disease forecasting for many crops

Table 1
Infection model parameters and evaluation by comparing model predictions with observations from published data.

Pathogen	Host	Disease	Ref. [a]	Estimated parameters [range from the literature]							Model evaluation	
				Y_{max} [b]	T_{min} [c]	T_{opt1} [d]	T_{opt2} [e]	T_{max} [f]	A [g]	B [h]	EF [i]	RRMSE [j]
Leptosphaeria maculans	Oilseed rape	*Phoma* leaf spot	(Toscano-Underwood et al., 2001)	0.311	3.33 [0;5]	15.15 [15;20]	16.28 [15;20]	29.83 [>20]	0.024	2.74	0.88	0.45
Phytophthora infestans	Potato	Late blight	(Maziero et al., 2009)	0.954	3.00 [0;11]	9.97 [10;24]	15.18 [10;24]	25.80 [25;28]	0.051	2.68	0.87	0.47
Plasmopara viticola	Grape	Downy mildew	(Lalancette et al., 1988)	0.085	4.79 [<5]	14.03 [15;24]	17.40 [15;24]	30.66 [30]	0.342	17.40	0.94	0.27
Puccinia triticina	Wheat	Leaf rust	(de Vallavieille-Pope et al., 1995)	0.436	1.86 [<5]	14.54 [12;20]	18.36 [12;20]	31.00 [28;30]	0.117	3.12	0.91	0.40
Pyrenophora teres	Barley	Net blotch	(Shaw, 1986)	0.345	1.94 [<4]	17.47 [13;18]	18.32 [13;18]	25.00 [25]	0.119	3.04	0.78	0.40

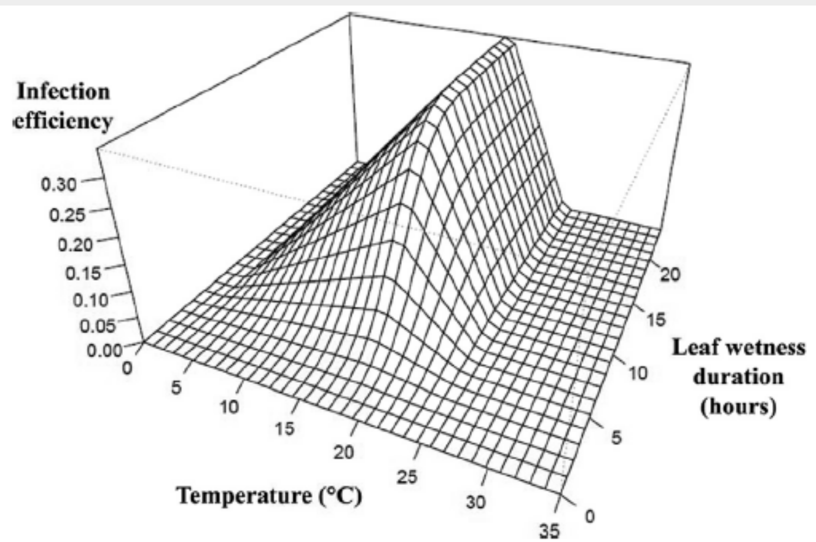


Fig. 1. Effects of temperature and leaf wetness duration on infection efficiency as predicted by the generic surface response function. This example shows the infection efficiency of *Puccinia triticina* ($Y_{max}=0.436$, $A=0.117$, $B=3.12$, $T_{min}=2\,°C$, $T_{opt1}=15\,°C$, $T_{opt2}=18\,°C$, and $T_{max}=31\,°C$).

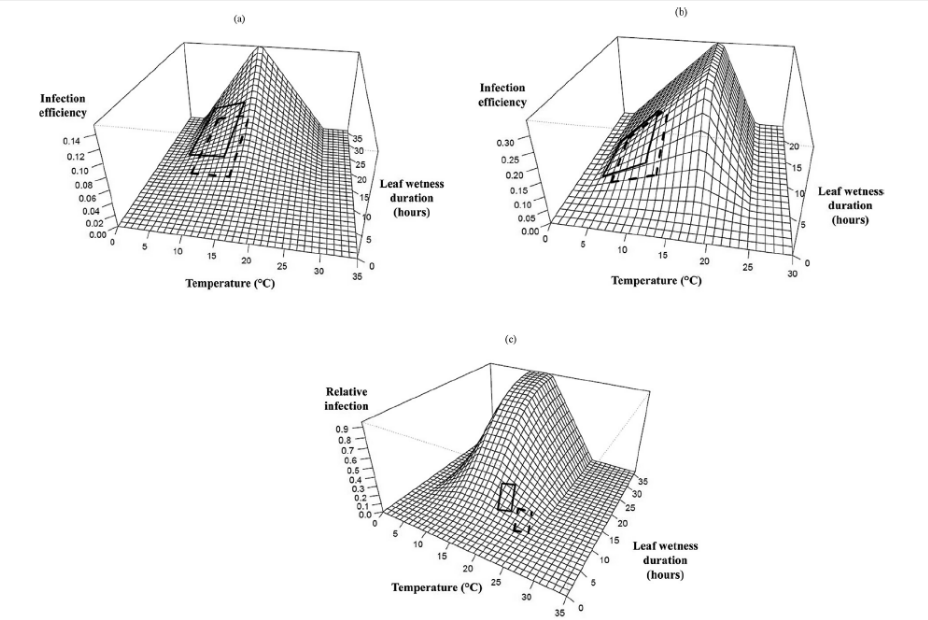
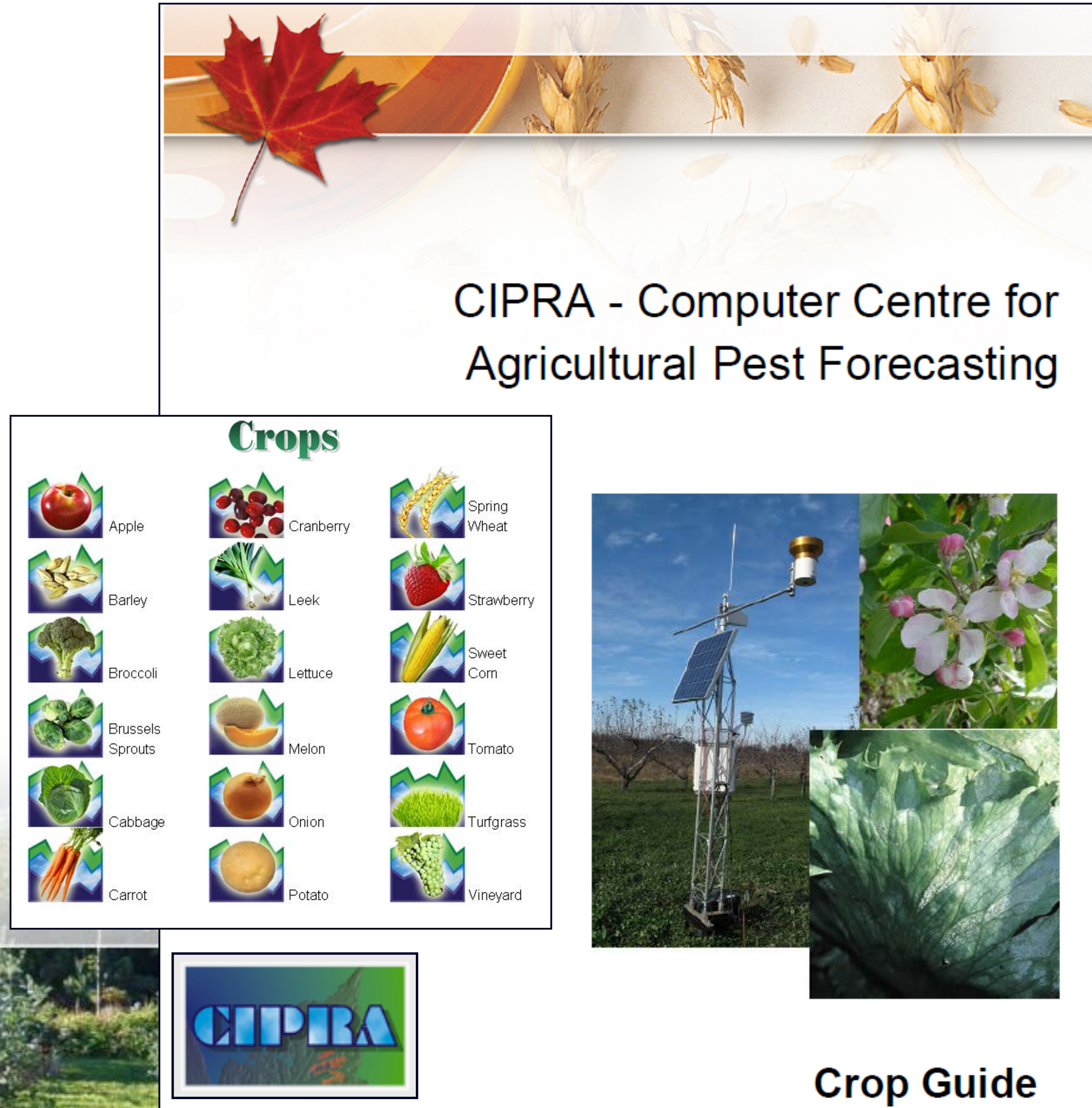


Fig. 3. Surface response of infection efficiency to temperature and leaf wetness duration for (a) *phoma* of oilseed rape, (b) net blotch of barley and (c) potato late blight. The rectangles depict the portions of the surface response corresponding to temperature and leaf wetness duration conditions in the recent past (—) and in the distant future (- - - -) during the months of (a) October and November, (b) March–May and (c) June–August.

For more information on bioclimatic models within CIPRA

- **Technical bulletin (Crop Guide) published in November 2014**
- **Available on-line**
- **Information**
  - ✓ Descriptions
  - ✓ References
  - ✓ Interpretations
  - ✓ Calibration / Validation



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CIPRA 2017:
A key tool for both "Biovigilance" and "Precision horticulture"

Bioclimatology & Modelling Research Team
Saint-Jean-sur-Richelieu R&D Centre (QC)
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